Balances on Reactive Systems

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Extent of reaction ξ:

$$(\nu_A \xi) \equiv \textit{moles A reacted}$$

$$N_2 + 3H_2 \rightarrow 2NH_3$$

ξ = moles N_2 reacted

3ξ = moles H_2 reacted

2ξ = moles NH_3 produced

f_A = fractional conversion

$$= \frac{\text{moles A reacted}}{\text{moles A fed}}$$

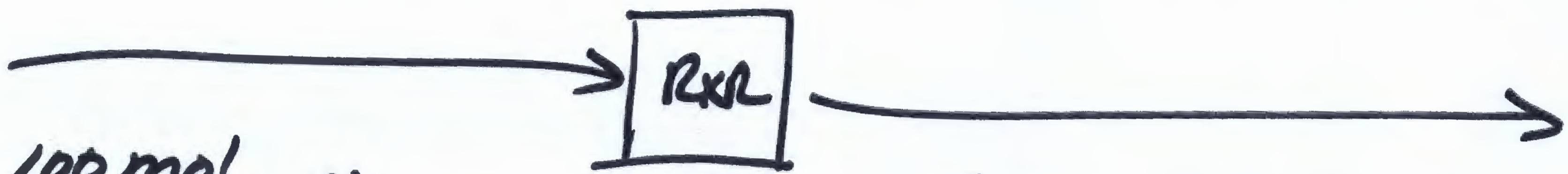
Problem: The feed to a continuous ammonia formation reactor is 100. mol/s nitrogen, 300. mol/s hydrogen, and 1.00 mol/s argon. The ammonia formation reaction is

$$N_2 + 3H_2 \rightarrow 2NH_3$$

The percent conversion of hydrogen in the reactor is 60.0%. What is the molar flow rate of each species as it exits the reactor?

$$N_2 + 3H_2 \rightarrow 2NH_3$$

$$f_{H_2} = 0.60 = \frac{\text{moles } H_2 \text{ reacted}}{\text{moles } H_2 \text{ fed}} = \frac{3\xi}{300}$$



Feed:

$100 \frac{mol}{s}$ N_2

$300 \frac{mol}{s}$ H_2

$1.00 \frac{mol}{s}$ Ar

Outlet:

$(100 - \xi) \frac{mol}{s}$ N_2

$(300 - 3\xi) \frac{mol}{s}$ H_2

$1.00 \frac{mol}{s}$ Ar

$2\xi \frac{mol}{s}$ NH_3

$$0.60 = \frac{3\xi}{300}$$

$$\boxed{\xi = 60}$$

EXIT STREAM

$N_2 = 100 - \xi = 40 \frac{mol}{s}\ N_2$

$H_2 = 300 - 3\xi = 120 \frac{mol}{s}\ H_2$

$Ar\ 1.00 \frac{mol}{s} = 1.00\ mol/s\ Ar$

$NH_3 : 2\xi = 120 \frac{mol}{s}\ NH_3$ //

Extent of reaction ξ:

$$(\nu_A \xi) \equiv moles\ A\ reacted$$